Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period: \_\_\_\_\_\_\_\_\_\_

**Unit 6, Part 2 Notes (DNA Replication)**

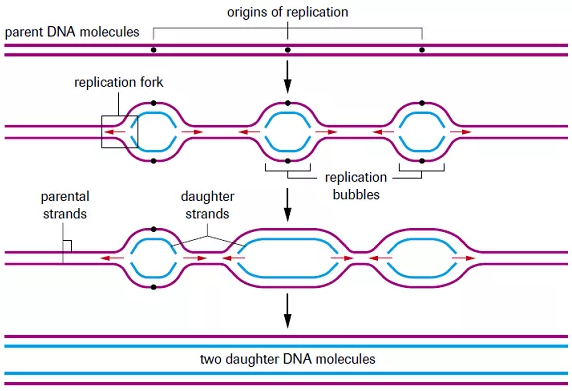
Pre-AP Biology, Mrs. Krouse

**A. Basic Facts about DNA Replication**

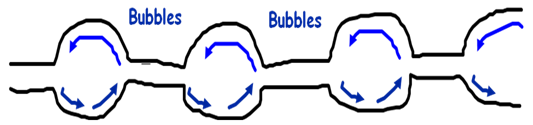
1. DNA replication must take place before a cell divides so that each \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ receives a full, identical copy of the genetic material from the parent cell.
2. DNA replication takes place during the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
3. DNA replication can begin at a place on the DNA double helix called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Beginning at this location, the DNA double helix is “unzipped” in both directions. (By “unzipped,” I mean that the two strands of DNA are separated from each other.)
4. When the DNA double helix is “unzipped” in both directions around the origin of replication, a “bubble” forms in the DNA called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

1. The two ends of the bubble where the strands are being unzipped are called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

***Note: You will need to add color-coding to the image below to distinguish between the parent (old) and daughter (new) strands of DNA.***



1. Prokaryotic cells have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ chromosome. They have so little DNA that they only need \_\_\_\_\_\_\_\_\_\_\_\_\_\_ origin of replication and replication bubble for DNA replication to occur efficiently.
2. Eukaryotic cells have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (line-shaped) chromosomes. They have so much DNA in these linear chromosomes that they have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ origins of replication and replication bubbles on each chromosome (see image below). This ensures that DNA replication occurs efficiently. Once eukaryotic chromosomes are replicated and coiled up during prophase of mitosis, they look like X’s.



**B. Steps of DNA Replication**

1. To explore the steps of DNA replication, let’s focus on one replication fork.
2. At this replication fork, the following events must occur…

-First, the enzyme \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is used to unwind and unzip the DNA double helix by breaking the weak \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_bonds between complementary nitrogen bases. It is necessary for the bonds between bases to be weak because DNA replication could not occur if helicase could not unzip the double helix.

***Let’s draw a picture that shows helicase unzipping the DNA and creating a replication fork.***

-Second, the enzyme \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ recognizes a sequence on the DNA strand where replication must begin. It creates a short chain of nucleotides (approximately 20 nucleotides long) with bases that match up with the complementary bases on the parent (old) DNA. This short new chain of nucleotides is called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. It serves as a \_\_\_\_\_\_\_\_\_\_\_\_\_ to tell the next enzyme (DNA polymerase) where to begin copying the DNA.

***Let’s draw a picture that shows primase creating a primer to match the base sequence on one of the parent strands of DNA.***

-Third, the enzyme \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ recognizes the primer and begins copying the old DNA strand at the primer. It gathers single nucleotides that are floating around in the nucleus (called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) and matches them up with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bases on the old DNA strand to build a new DNA strand. The old DNA strand can also be called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_DNA strand, and the new DNA strand can also be called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DNA strand.

*Remember: An enzyme is a type of protein that assists and speeds up a reaction. An example of a process involving a complex set of reactions is DNA replication! As such, there are many different types of enzymes that assist with DNA replication.*

-DNA polymerase “reads” the bases on the parent strand moving from the parent DNA strand’s 3’ end towards its 5’ end. This means it is building the daughter DNA strand from its 5’ end towards its 3’ end. (We know this because the parent DNA strand and the daughter DNA strand must be antiparallel to each other.)

-We can remember this using the following memory trick:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Let’s draw a picture that shows DNA polymerase building one of the daughter strands starting at the primer.***

-Because the parent DNA must be read in the 3’ to 5’ direction, one of the daughter DNA strands gets built towards (into) the replication fork and the other gets built away from (out of) the replication fork.

-The new DNA strand that gets built into the replication fork is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. The new DNA strand that gets built out of the replication fork is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

-The lagging strand must be built in chunks called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because DNA polymerase must keep backtracking as the replication fork opens up further to continue building new DNA in the direction out of the fork. The Okazaki fragments are later sealed together by an enzyme called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Gluing the chunks of the lagging strand together is the fourth and final step of DNA replication.

-We often say that the leading strand is built \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, which means it is built in one long piece. We also say that the lagging strand is built \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, which means it is built in multiple small pieces/chunks.

***Let’s draw a picture that shows the leading and lagging daughter DNA strands.***

***Let’s draw a picture that shows why the lagging strand is built in chunks.***

***Let’s draw a picture that shows ligase sealing together the chunks of the lagging strand.***

1. The result of DNA replication is two double helices (called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ double helices) that are identical to one another. Each daughter double helix contains one strand of daughter DNA and one strand of parent DNA. Scientists often say that DNA replication is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because one parent DNA strand is “conserved” (kept) in each daughter double helix. This is called the “semi-conservative model of DNA replication.”

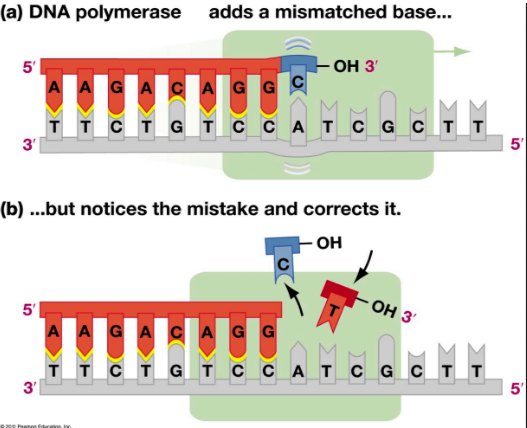
***Let’s draw a picture of the semi-conservative model of DNA replication.***

Before scientists knew that DNA replication was semi-conservative, they hypothesized that it could be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. If this was the case, each parent DNA strand would still be used to build a daughter DNA strand. However, after replication was complete, the two parent DNA strands would wind back together to create one of the resulting double helices, and the two daughter DNA strands would wind together to create the other resulting double helix. Thus, the original parent double helix would be “conserved” (kept) in one of the daughter double helices. This is called the “conservative model of DNA replication.” Remember, this model is NOT correct.

***Let’s draw a picture of the conservative model of DNA replication.***

**C. What happens if there is an error in the DNA base sequence?**

1. **During DNA Replication:** Sometimes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ makes an error and matches the wrong free nucleotide with the base on the parent strand. It is often able to recognize its error and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ it by removing the incorrect free nucleotide and bringing in the correct free nucleotide, which is complementary to the base on the parent strand (see image below). Without proofreading, DNA polymerase makes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ base pairing errors. With proofreading, this error rate reduces to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.



1. **Any Time During the Cell Cycle**: Certain chemicals, UV light, etc. can damage the DNA and cause changes to the base sequence (also known as the base pair sequence). These changes are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_and the chemicals, UV light, etc. that cause the mutations are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. (In Part 3 of this unit, we will learn about different types of mutations.)

Certain enzymes in the cell are able to remove damaged DNA. (These enzymes are called exonucleases, but you don’t need to know this!) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ can then come in and create the correct nucleotide/base sequence. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is then used to seal the newly-made chain of nucleotides with the cut ends of the original DNA strand. This is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. (Note: to “excise” means to cut.)

One example of excision repair occurs when DNA is damaged by UV light. UV light can cause thymine bases that are next to each other on a strand of DNA to form covalent bonds with each other, which alters the shape of the DNA at this location. The covalently-bonded thymine bases are called a thymine dimer (because “di” means two). When there is a thymine dimer present, DNA replication cannot take place, which is a big problem! Thankfully, exonuclease enzymes can cut out the thymine dimer and the bases directly surrounding the dimer. DNA polymerase can then make a new chain of nucleotides, and ligase can seal the new chain with the old DNA strand that surrounds it (see image below).

